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For: **LIQUID CRYSTAL DISPLAY  
APPARATUS AND METHOD OF  
MANUFACTURING SUBSTRATE  
OF THE SAME**

Docket No.: **6192.0329.US**

# LIQUID CRYSTAL DISPLAY APPARATUS AND METHOD OF MANUFACTURING SUBSTRATE OF THE SAME

## CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application relies for priority upon Korean Patent Application No.2003-55738 filed on August 12, 2003, the contents of which are herein incorporated by reference in its entirety.

## BACKGROUND OF THE INVENTION

### 10 1. Field of the Invention

The present invention relates to a liquid crystal display apparatus and a method of manufacturing a substrate of the liquid crystal display apparatus, and more particularly to a liquid crystal display apparatus with retardation layer formed in a liquid crystal display panel and a manufacturing a substrate of the liquid crystal 15 display apparatus.

### 2. Description of the Related Art

A general retardation film is used for a liquid crystal display apparatus. The retardation film allows a linearly polarized light to pass through the retardation film. 20 The linearly polarized light is refracted in two directions due to a difference of velocity.

A first linearly polarized light that is referred to as 'ordinary light' is refracted according to Snell's law. However, a second polarized light that is referred to as 'extraordinary light' is refracted against the Snell's law. The retardation film applies different phases to the ordinary light and the extraordinary light.

25 Particularly, the retardation film of which optic axis is tilted with respect to a

surface or normal line of the retardation film, compensates light that passes through the liquid crystal display apparatus. Thus, the retardation film increases viewing angle of the liquid crystal display apparatus.

FIG. 1 is a schematic view showing a general liquid crystal display apparatus.

Referring to FIG. 1, a general liquid crystal display apparatus includes an array substrate 10, a color filter substrate 20, a liquid crystal layer 30, a first retardation film 42, a first polarizing plate (or polarizer) 44, a second retardation film 46 and a second polarizing plate (or analyzer) 48. The array substrate 10 includes a first transparent substrate 12, a pixel electrode 14 and a first alignment film 16.

The pixel electrode 14 is formed on the first transparent substrate 12. The first alignment film 16 is formed on the pixel electrode 14.

The color filter substrate 20 includes a second transparent substrate 22, a color filter layer 24, protection layer 26, a common electrode layer 28 and a second alignment film 29. The color filter layer 24 is formed on the second transparent substrate 22. The protection layer 26 is formed on the color filter layer 24. The common electrode layer 28 is formed on the protection layer 26. The second alignment film 29 is formed on the common electrode layer 28. The liquid crystal layer is interposed between the array substrate 10 and the color filter substrate 20. The first retardation film 42 is disposed on a backside of the first transparent substrate 12. The first polarizing plate 44 is disposed on the first retardation film 42. The second retardation film 46 is disposed on a backside of the second transparent substrate 46. The second polarizing plate 48 is disposed on the second retardation film 46.

When electric fields are formed between the pixel electrode 14 and the common electrode layer 28, liquid crystal molecules of the liquid crystal layer 30 are

erected (Homogeneous phase) or laid (Homeotropic phase) with respect to the array substrate 10 and the color filter substrate 20.

FIG. 2A is a plan view showing vertical angles formed between a first polarizing axis of a first polarizing plate and a second polarizing axis of a second polarizing plate, and FIG. 2B is a perspective view showing vertical angles formed between a first polarizing axis of a first polarizing plate and a second polarizing axis of a second polarizing plate.

Referring to FIG. 2A, when the liquid crystal molecules are erected (or vertically aligned), a light is not leaked in a normal direction of the liquid crystal display apparatus because a polarizing axis of the first and second polarizing plates are substantially orthogonal to each other.

Referring to FIG. 2B, the light is leaked in a tilted direction because the polarizing axis of the first and second polarizing plate are not orthogonal to each other. Thus, a contrast ratio decreases, so that a display quality is deteriorated.

In order to reduce the leakage of the light, a retardation film such as a biaxial film and uni-axial film is disposed at backsides of the first and second transparent substrates 12 and 22 together with the first and second polarizing plates 44 and 48.

The retardation film increases a cost of manufacturing the liquid crystal display apparatus.

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## SUMMARY OF THE INVENTION

Accordingly, the present invention is provided to substantially obviate one or more problems due to limitations and disadvantages of the related art.

It is a feature of the present invention to provide a liquid crystal display apparatus with retardation layer interposed between substrates of a liquid crystal

display panel.

It is another feature of the present invention to provide a method of manufacturing a color filter substrate for the liquid crystal display apparatus.

It is still another feature of the present invention to provide a method of  
5 manufacturing an array substrate for the liquid crystal display apparatus.

In one aspect of the liquid crystal display apparatus, the liquid crystal display apparatus includes a lower substrate, an upper substrate, a liquid crystal layer and a retardation layer. The lower substrate includes a first transparent substrate. The upper substrate faces the first transparent substrate. The upper substrate includes  
10 a second transparent substrate. The liquid crystal layer is interposed between the lower substrate and the upper substrate. The retardation layer is interposed between the first and second transparent substrates. The retardation layer compensates phase difference of light that passes through the liquid crystal layer.

According to the method of manufacturing a color filter substrate, a color filter  
15 layer is formed on a transparent substrate. A liquid crystal material is coated on the color filter layer. An ultraviolet light is irradiated onto the liquid crystal material to form a retardation layer with a fixed alignment of liquid crystal molecules of the liquid crystal material, the retardation layer. A common electrode layer is formed on the retardation layer. Then, an alignment film is formed on the common electrode layer.

20 According to another method of manufacturing a color filter substrate, a color filter layer is formed on a transparent substrate. A protection layer is formed on the color filter layer. A liquid crystal material is coated on the protection layer. An ultraviolet light is irradiated onto the liquid crystal material to form a retardation layer with a fixed alignment of liquid crystal molecules of the liquid crystal material, the  
25 retardation layer. A common electrode layer is formed on the retardation layer.

Then, an alignment film is formed on the common electrode layer.

According to another method of manufacturing a color filter substrate, a color filter layer is formed on a transparent substrate. A protection layer is formed on the color filter layer. A common electrode layer is formed on the protection layer. A 5 liquid crystal material is coated on the common electrode layer. An ultraviolet light is irradiated onto the liquid crystal material to form a retardation layer with a fixed alignment of liquid crystal molecules of the liquid crystal material, the retardation layer. Then, an alignment film is formed on the retardation layer.

According to the liquid crystal display apparatus and the method of this 10 invention, the retardation layer takes the place of the retardation film of a general liquid crystal display apparatus, which disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.

Therefore, a number of films for the liquid crystal display apparatus and a number of processes are reduced to save a manufacturing cost.

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#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other features and advantage points of the present invention will become more apparent by describing in detailed exemplary embodiments thereof with reference to the accompanying drawings, in which:

20 FIG. 1 is a schematic view showing a general liquid crystal display apparatus;

FIG. 2A is a plan view showing vertical angles formed between a first polarizing axis of a first polarizing plate and a second polarizing axis of a second polarizing plate;

25 FIG. 2B is a perspective view showing vertical angles formed between a first polarizing axis of a first polarizing plate and a second polarizing axis of a second

polarizing plate;

FIG. 3 is a cross-sectional view showing a liquid crystal display apparatus according to a first exemplary embodiment;

FIG. 4 is a schematic view showing an arrangement of cholesteric liquid  
5 crystal molecules;

FIGS. 5A through 5D are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 3;

FIG. 6 is a cross-sectional view showing a liquid crystal display apparatus according to a second exemplary embodiment of the present invention;

10 FIGS. 7A through 7E are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 6;

FIG. 8 is a cross-sectional view showing a liquid crystal display apparatus according to a third exemplary embodiment of the present invention;

15 FIGS. 9A through 9E are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 8;

FIG. 10 is cross-sectional view showing a liquid crystal display apparatus according to a fourth exemplary embodiment of the present invention; and

FIGS. 11A through 11E are cross-sectional views showing a process of manufacturing an array substrate of FIG. 10.

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## **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Hereinafter, the preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

25

### **Embodiment 1**

FIG. 3 is a cross-sectional view showing a liquid crystal display apparatus according to a first exemplary embodiment. In the present embodiment, a retardation layer is formed on a protection layer.

Referring to FIG. 3, a liquid crystal display apparatus according to a first exemplary embodiment includes an array substrate 100, a color filter substrate 200, a liquid crystal layer 300, and first and second polarizing plates 410 and 420. The liquid crystal layer 300 is interposed between the array substrate 100 and the color filter substrate 200. The first polarizing plate 410 is disposed under a backside of the array substrate 100. The second polarizing plate 420 is disposed over a backside of the color filter substrate 200.

The array substrate 100 includes a first transparent substrate 105, a gate insulation layer 112, a switching device TFT, a passivation layer 140, an organic insulation layer 144, a pixel electrode 150 and a first alignment film 160.

The switching device TFT includes a gate electrode 110, a gate insulation layer 112, a semiconductor layer 114, an ohmic contact layer 116, a source electrode 120 and a drain electrode 130.

The gate insulation layer 112 is formed on the first transparent substrate 105, such that the gate insulation layer 112 covers the gate electrode 110 of the switching device TFT.

The passivation layer 140 covers the switching device TFT, such that a portion of the drain electrode 130 of the switching device TFT is exposed.

The organic insulation layer 144 is formed on the passivation layer 140, such that the portion of the drain electrode 130 of the switching device TFT is exposed.

The pixel electrode 150 is formed on the organic insulation layer 144, such that the pixel electrode makes contact with the drain electrode 130 of the switching

device TFT via a contact hole 141. The pixel electrode 150 comprises indium tin oxide (ITO) or indium zinc oxide (IZO), so that pixel electrode 150 is transparent and electrically conductive.

The first alignment film 160 is formed on the pixel electrode 150.

Not shown in FIG. 3, when the liquid crystal display apparatus corresponds to independent wiring type, a wiring for capacitance is separately formed, such that the wiring is spaced apart from the switching device TFT. The wiring and the pixel electrode 150 define a storage capacitor Cst. The liquid crystal display apparatus may correspond to a previous gate type.

The color filter substrate 200 includes a second transparent substrate 205, a black matrix 210, a color filter layer 220, a retardation layer 230, a common electrode layer 240 and a second alignment film 250.

The black matrix 210 is formed on the second transparent substrate 205, such that the black matrix 210 faces the switching device. Thus, the black matrix 250 hides the switching device.

The color filter layer 220 includes a red pixel region, a green pixel region and a blue pixel region. The black matrix 210 divides the red pixel region, the green pixel region and the blue pixel region. An edge of the red pixel region, the green pixel region and the blue pixel region may overlap with each other, so that the edge may hide the switching device TFT as a substitute of the black matrix 210.

The retardation layer 230 is formed on the black matrix 210 and the color filter layer 220. The retardation layer 230 protects the black matrix 210 and the color filter layer 220. The retardation layer 230 compensates a phase difference of a light that passes through the liquid crystal layer 300. The light may be generated from a backlight assembly (not shown) in a transmissive type liquid crystal display

apparatus. The light may correspond to a natural light that enters into the liquid crystal display apparatus via the backside of the color filter substrate 200 in a reflective type liquid crystal display apparatus. The light may be generated from the backlight assembly or correspond to the natural light in a transmissive and reflective 5 type liquid crystal display apparatus.

The retardation layer 230 may comprise a liquid crystal polymer that is hardened when an ultraviolet light is irradiated. For example, the retardation layer 230 comprises cholesteric liquid crystal.

FIG. 4 is a schematic view showing an arrangement of cholesteric liquid 10 crystal molecules.

Referring to FIG. 4, a director 'n' of cholesteric liquid crystal (or chiral nematic liquid crystal) molecules rotates gradually in a z-axis direction to form a spiral shape. That is, the director n is expressed in an expression,  $n = (\cos 2\pi/p, \sin 2\pi/p, 0)$ . A period of rotation 'p' is characterized by the cholesteric liquid crystal. An axis of the 15 spiral shape corresponds to an optic axis. In a microscopic view, the cholesteric liquid crystal molecules are arranged, such that each of the cholesteric liquid crystal molecules has the same director likewise the twisted nematic liquid crystal molecules.

However, in a macroscopic view, the directors of the cholesteric liquid crystal molecules are arranged in a circular shape.

20 Referring again to FIG. 3, the cholesteric liquid crystal material is coated on the retardation layer 220. Then, an ultraviolet light is irradiated onto the cholesteric liquid crystal material to harden the cholesteric liquid crystal material. Thus, directors of the liquid crystal molecules are fixed, so that the retardation layer 230 performing a function of a biaxial film or uni-axial film is formed.

25 In detail, when a polarized ultraviolet light is irradiated onto a film including the

cholesteric liquid crystal material, the biaxial film is formed. When a non-polarized ultraviolet light is irradiated onto a film including the cholesteric liquid crystal material, a C-plate film is formed.

In case of the biaxial film, a refractivity of x-direction  $n_x$ , a refractivity of y-  
5 direction  $n_y$  and a refractivity of z-direction  $n_z$  are different from each other.

The uni-axial film is divided into an A-plate film and C-plate film. In case of the A-plate film, the refractivity of y-direction  $n_y$  is substantially equal to the refractivity of z-direction  $n_z$ . The refractivity of y-direction  $n_y$  and the refractivity of z-direction  $n_z$  are less than the refractivity of x-direction  $n_x$  ( $n_x > n_y = n_z$ ).

10 In case of the C-plate film, the refractivity of x-direction  $n_x$  is substantially equal to the refractivity of y-direction  $n_y$ . The refractivity of x-direction  $n_x$  and the refractivity of y-direction  $n_y$  are greater than the refractivity of z-direction  $n_z$  ( $n_x = n_y > n_z$ ).

15 The retardation layer 230 may be formed via a spin coating method, a micro gravure coating method or a capillary coating method. In the spin coating method, an amount of material that is disused is larger than an amount of material that is used for coating. Thus, the retardation layer 230 is preferably formed via the micro gravure coating method disclosed in U.S.A. patent number 4,791,881 or the capillary coating method.

20 The retardation layer 230 may include reactive mesogen mixture (RMM), polyvinylalchol (PVA), polycarbonate (PC), or cycloolefin polymer (COP).

25 The common electrode layer 240 is formed on the retardation layer 230. A reference voltage  $V_{com}$  is applied to the common electrode layer 240. Thus, electric fields are formed between the common electrode layer 240 and the pixel electrode 150 where a pixel voltage is applied.

The second alignment layer 250 is formed on the common electrode layer 240. The second alignment layer 250 aligns the liquid crystal molecules. When the common electrode layer 240 may not be formed, the second alignment layer 250 may be formed on the retardation layer 230.

5       The liquid crystal layer 300 is interposed between the array substrate 100 and the color filter substrate 240. When the pixel voltage is applied to the pixel electrode 150, the electric fields are formed between the array substrate 100 and the color filter substrate 200. Thus, liquid crystal molecules are rearranged according to the electric fields. The liquid crystal layer 300 may correspond to a twisted  
10 nematic (TN) mode, a vertical alignment (VA) mode or optically compensated birefringence (OCB) mode.

The first polarizing plate (or polarizer) 410 is disposed under the array substrate 100, so that a polarized light enters the array substrate 100 via the first polarizing plate 410.

15       The second polarizing plate (or analyzer) 420 is disposed over the color filter substrate 200, so that the polarized light is analyzed via the second polarizing plate 420.

FIGS. 5A through 5D are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 3.

20       Referring to FIG. 5A, a metal layer including chromium (Cr) is deposited on a second transparent substrate 205. A photoresist is deposited on the metal layer. Then, the photoresist is exposed and developed selectively via a photomask (not shown). Thus, a black matrix 210 including the chromium (Cr) is formed. The black matrix 210 is disposed such that the black matrix 210 faces a switching device  
25 of an array substrate when a color filter substrate and an array substrate are

assembled together.

Then, a photosensitive red-colored resist is deposited on the second transparent substrate 205. Then, the red-colored resist is exposed and developed, so that red color filter is formed. Green color filter and blue color filter are formed  
5 via same process. Thus, color filter layer 220 is formed.

Referring to FIG. 5B, a liquid crystal polymer such as cholesteric liquid crystal material is coated on the color filter layer 220. The liquid crystal molecules of the cholesteric liquid crystal material are aligned. Then, an ultraviolet light is irradiated onto the cholesteric liquid crystal material to fix the alignment of the liquid crystal  
10 molecules. Thus, a retardation layer 230 is formed. When the ultraviolet light is polarized, the retardation layer 230 corresponds to a biaxial film. However, when the ultraviolet light is not polarized, the retardation layer 230 corresponds to a C-plate film.

Referring to FIG. 5C, a common electrode layer 240 is formed on a  
15 retardation layer 230. The common electrode layer 240 comprises a transparent and electrically conductive material such as indium tin oxide (ITO) and indium zinc oxide (IZO).

Referring to FIG. 5D, an alignment film 250 is formed on the common electrode layer 240. The alignment film 250 allows liquid crystal molecules to  
20 arrange toward a predetermined direction. The alignment film 250 may include an inorganic material or an organic material as long as the alignment film 250 forms a pre-tilt angle of liquid crystal molecule.

The inorganic material for the alignment film 250 may comprise silicon oxide ( $\text{SiO}_2$ ), a metal oxide such as magnesium oxide ( $\text{MgO}$ ), magnesium fluoride ( $\text{MgF}_2$ ),  
25 gold (Au), etc. When the inorganic material is used for the alignment film 250, an

inorganic material is deposited in a predetermined direction. Thus, a separate aligning process is not necessary.

The organic material for the alignment film 250 may comprise a resin such as, polyimide and polyvinyl alcohol, a silane compound that may be absorbed on a 5 substrate, and polyamic acid that may be formed in a thin film. When the organic material is used for the alignment film 250, the separate aligning process is necessary.

That is, the organic material may be rubbed, or a polarized ultraviolet light may be irradiated.

10 Further, the alignment film 250 may be formed in a single layered structure comprising one material, or a multi-layered structure comprising at least two materials. For example, an inorganic layer is formed at first. Then, an organic layer is formed on the inorganic layer. When the aligning film 250 is formed in the multi-layered structure, a vertical aligner such as lecithin may be added to the 15 organic material.

The color filter substrate 200 of FIG. 3 is formed via a process described in FIGS. 5A – 5D. When the color filter substrate 200 is completed, the color filter substrate 200 is assembled with the array substrate 100. Then, liquid crystal material is interposed between the array substrate 100 and the color filter substrate 20 200 to form the liquid crystal layer 300. The liquid crystal layer 300 may be formed before the array substrate 100 and the color filter substrate are assembled with each other.

As described above, the retardation layer formed on the color filter layer protects the color filter layer. Further, the ultraviolet light is irradiated onto the 25 retardation layer comprising a cholesteric liquid crystal, so that the retardation layer

compensates a phase difference. Thus, the retardation layer takes the place of the retardation film of a general liquid crystal display apparatus, which is disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.

5 Therefore, a number of films for the liquid crystal display apparatus and a number of processes are reduced to save a manufacturing cost.

### Embodiment 2

FIG. 6 is a cross-sectional view showing a liquid crystal display apparatus  
10 according to a second exemplary embodiment of the present invention. The liquid  
crystal display apparatus is same as in Embodiment 1 except for a protection layer.  
Thus, the same reference numerals will be used to refer to the same or like parts as  
those described in Embodiment 1 and any further explanation will be omitted.

Referring to FIG. 6, a liquid crystal display apparatus according to a second  
15 exemplary embodiment includes an array substrate 100, a color filter substrate 200,  
a liquid crystal layer 300, and first and second polarizing plates 410 and 420. The  
liquid crystal layer 300 is interposed between the array substrate 100 and the color  
filter substrate 200. The first polarizing plate 410 is disposed under a backside of  
the array substrate 100. The second polarizing plate 420 is disposed over a  
20 backside of the color filter substrate 200.

The color filter substrate 200 includes a second transparent substrate 205, a  
black matrix 210, a color filter layer 220, a protection layer 232, a retardation layer  
234, a common electrode layer 240 and a second alignment film 250.

25 The black matrix 210 is formed on the second transparent substrate 205, such  
that the black matrix 210 faces the switching device. Thus, the black matrix 210

hides the switching device.

The color filter layer 220 includes a red pixel region, a green pixel region and a blue pixel region. The black matrix 210 defines the red pixel region, the green pixel region and the blue pixel region. An edge of the red pixel region, the green 5 pixel region and the blue pixel region may overlap with each other, so that the edge may hide the switching device TFT as a substitute of the black matrix 210.

The protection layer 232 is formed on the black matrix 210 and the color filter layer 220. The protection layer 232 protects the black matrix 210 and the color filter layer 220.

10 The retardation layer 234 is formed on the protection layer 232. The retardation layer 234 compensates a phase difference of a light that passes through the liquid crystal layer 300.

15 The retardation layer 234 may comprise a liquid crystal polymer that is hardened when an ultraviolet light is irradiated. For example, the retardation layer 230 comprises cholesteric liquid crystal.

FIGS. 7A through 7E are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 6.

Referring to FIG. 7A, a metal layer including chromium (Cr) is deposited on a second transparent substrate 205. A photoresist is deposited on the metal layer. 20 Then, the photoresist is exposed and developed selectively via a photomask (not shown). Thus, a black matrix 210 including the chromium (Cr) is formed. The black matrix 210 is disposed such that the black matrix 210 faces a switching device of an array substrate when a color filter substrate and an array substrate are assembled together.

25 Then, a photosensitive red-colored resist is deposited on the second

transparent substrate 205. Then, the red-colored resist is exposed and developed, so that red color filter is formed. Green color filter and blue color filter are formed via same process. Thus, color filter layer 220 is formed.

Referring to FIG. 7B, a protection layer 232 is formed on the color filter layer 220 to protect the color filter layer 220.

Referring to FIG. 7C, a liquid crystal polymer such as cholesteric liquid crystal material is coated on the protection layer 232. The liquid crystal molecules of the cholesteric liquid crystal material are aligned. Then, an ultraviolet light is irradiated onto the cholesteric liquid crystal material to fix the alignment of the liquid crystal molecules. Thus, a retardation layer 234 is formed. When the ultraviolet light is polarized, the retardation layer 234 corresponds to a biaxial film. However, when the ultraviolet light is not polarized, the retardation layer 234 corresponds to a C-plate film.

The retardation layer 234 may be formed via a spin coating method, a micro gravure coating method or a capillary coating method. Preferably, the retardation layer 234 is formed via the micro gravure coating method or the capillary coating method.

The retardation layer 234 may include reactive mesogen mixture (RMM), polyvinylalchol (PVA), polycarbonate (PC), or cycloolefin polymer (COP).

Referring to FIGS. 7D and 7E, a common electrode layer 240 is formed on a retardation layer 234. The common electrode layer 240 comprises a transparent and electrically conductive material such as indium tin oxide (ITO) and indium zinc oxide (IZO). Then, an alignment film 250 is formed on the common electrode layer 240. The alignment film 250 allows liquid crystal molecules to arrange toward a predetermined direction. The alignment film 250 may include an inorganic material

or an organic material as long as the alignment film 250 forms a pre-tilt angle of liquid crystal molecule. In FIG. 7E, the alignment film 250 is formed on the common electrode layer 240. However, when the common electrode layer 240 is not formed, the alignment film 250 may be formed on the retardation layer 240.

5       The color filter substrate 200 of FIG. 6 is formed via a process described in FIGS. 7A through 7E. When the color filter substrate 200 is completed, the color filter substrate 200 is assembled with the array substrate 100. Then, liquid crystal material is interposed between the array substrate 100 and the color filter substrate 200 to form the liquid crystal layer 300. The liquid crystal layer 300 may be formed  
10 before the array substrate 100 and the color filter substrate are assembled with each other.

As described above, the ultraviolet light is irradiated onto the retardation layer comprising a cholesteric liquid crystal, so that the retardation layer compensates a phase difference. Thus, the retardation layer interposed between the protection 15 layer and the common electrode takes the place of the retardation film of a general liquid crystal display apparatus, which is disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.

Therefore, a number of films for the liquid crystal display apparatus and a number of processes are reduced to save a manufacturing cost.

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### Embodiment 3

FIG. 8 is a cross-sectional view showing a liquid crystal display apparatus according to a third exemplary embodiment of the present invention. In the present embodiment, a retardation layer is disposed on an alignment film.

25       Referring to FIG. 8, a liquid crystal display apparatus according to a third

exemplary embodiment includes an array substrate 100, a color filter substrate 200, a liquid crystal layer 300, and first and second polarizing plates 410 and 420. The liquid crystal layer 300 is interposed between the array substrate 100 and the color filter substrate 200. The first polarizing plate 410 is disposed under a backside of 5 the array substrate 100. The second polarizing plate 420 is disposed over a backside of the color filter substrate 200.

The color filter substrate 200 includes a second transparent substrate 205, a black matrix 210, a color filter layer 220, a protection layer 232, a common electrode layer 240, a retardation layer 234 and a second alignment film 250.

10 The black matrix 210 is formed on the second transparent substrate 205, such that the black matrix 210 faces a switching device TFT. Thus, the black matrix 210 hides the switching device TFT.

15 The color filter layer 220 includes a red pixel region, a green pixel region and a blue pixel region. The black matrix 210 defines the red pixel region, the green pixel region and the blue pixel region. An edge of the red pixel region, the green pixel region and the blue pixel region may overlap with each other, so that the edge 20 may hide the switching device TFT as a substitute of the black matrix 210.

The protection layer 232 is formed on the black matrix 210 and the color filter layer 220. The protection layer 232 protects the black matrix 210 and the color filter 25 layer 220.

The common electrode layer 240 is formed on the protection layer 232. The common electrode layer 240 receives a reference voltage  $V_{com}$ . When a pixel voltage is applied to a pixel electrode 150 of an array substrate 100, electric fields are formed between the common electrode layer 240 and a pixel electrode 150 to 25 rearrange liquid crystal molecules of a liquid crystal layer 300.

The retardation layer 234 is formed on the common electrode layer 240. The retardation layer 234 compensates a phase difference of a light that passes through the liquid crystal layer 300. The retardation layer 234 is made of liquid crystal polymer that is hardened when an ultraviolet light is irradiated. For example, the 5 retardation layer 234 comprises cholesteric liquid crystal.

In a process of manufacturing the color filter substrate, a cholesteric liquid crystal material is coated on the common electrode 240. An ultraviolet light is irradiated onto the cholesteric liquid crystal material to fix an arrangement of cholesteric liquid crystal molecules. Thus, the retardation layer 234 that operates 10 as a biaxial film or uni-axial film is formed. When a polarized ultraviolet light is irradiated onto to the cholesteric liquid crystal material, the retardation layer 234 operates as the biaxial film. When a non-polarized ultraviolet light is irradiated onto the cholesteric liquid crystal material, the retardation layer 234 operates as a C-plate film that belongs to the uni-axial film.

15 The retardation layer 234 may be formed via a spin coating method, a micro gravure coating method or a capillary coating method. Preferably, the retardation layer 234 is formed via the micro gravure coating method or the capillary coating method.

20 The retardation layer 234 may include reactive mesogen mixture (RMM), polyvinylalchol (PVA), polycarbonate (PC), or cycloolefin polymer (COP).

The second alignment film 250 is formed on the retardation layer 234.

FIGS. 9A through 9E are cross-sectional views showing a process of manufacturing a color filter substrate of FIG. 8.

25 Referring to FIG. 9A, a metal layer including chromium (Cr) is deposited on a second transparent substrate 205. A photoresist is deposited on the metal layer.

Then, the photoresist is exposed and developed selectively via a photomask (not shown). Thus, a black matrix 210 including the chromium (Cr) is formed. The black matrix 210 is disposed such that the black matrix 210 faces a switching device of an array substrate when a color filter substrate and an array substrate are  
5 assembled together.

Then, a photosensitive red-colored resist is deposited on the second transparent substrate 205. Then, the red-colored resist is exposed and developed, so that red color filter is formed. Green color filter and blue color filter are formed via same process. Thus, color filter layer 220 is formed.

10 Referring to FIG. 9B, a protection layer 232 is formed on the color filter layer 220 to protect the color filter layer 220.

Referring to FIG. 9C, a common electrode layer 240 is formed on the protection layer 232. The common electrode 240 comprises an electrically conductive and transparent material such as indium tin oxide (ITO) or indium zinc oxide (IZO).  
15

Referring to FIG. 9D, a cholesteric liquid crystal material is coated on the common electrode layer 240. An ultraviolet light is irradiated onto the cholesteric liquid crystal material to fix an arrangement of cholesteric liquid crystal molecules. Thus, the retardation layer 234 that operates as a biaxial film or uni-axial film is  
20 formed. When a polarized ultraviolet light is irradiated onto to the cholesteric liquid crystal material, the retardation layer 234 operates as the biaxial film. When a non-polarized ultraviolet light is irradiated onto the cholesteric liquid crystal material, the retardation layer 234 operates as a C-plate film that belongs to the uni-axial film.

Referring to FIG. 9E, an alignment film 250 is formed on the retardation layer  
25 234 for pre-tilting liquid crystal molecules.

As described above, a retardation layer that is interposed between the common electrode layer and the alignment film takes the place of the retardation film of a general liquid crystal display apparatus, which is disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.

5 Therefore, a number of films for the liquid crystal display apparatus and a number of processes are reduced to save a manufacturing cost.

#### Embodiment 4

FIG. 10 is cross-sectional view showing a liquid crystal display apparatus according to a fourth exemplary embodiment of the present invention. The liquid crystal display apparatus is same as in Embodiment 3 except for position of retardation layer. Thus, the same reference numerals will be used to refer to the same or like parts as those described in Embodiment 3 and any further explanation will be omitted.

15 Referring to FIG. 10, a liquid crystal display apparatus according to a fourth exemplary embodiment includes an array substrate 100, a color filter substrate 200, a liquid crystal layer 300, and first and second polarizing plates 410 and 420. The liquid crystal layer 300 is interposed between the array substrate 100 and the color filter substrate 200. The first polarizing plate 410 is disposed under a backside of 20 the array substrate 100. The second polarizing plate 420 is disposed over a backside of the color filter substrate 200.

The array substrate 100 includes a first transparent substrate 105, a gate insulation layer 112, a switching device TFT, a passivation layer 140, an organic insulation layer 144, a pixel electrode 150, a retardation layer 152 and a first 25 alignment film 160.

The switching device TFT includes a gate electrode 110, a gate insulation layer 112, a semiconductor layer 114, an ohmic contact layer 116, a source electrode 120 and a drain electrode 130.

The gate insulation layer 112 is formed on the first transparent substrate 105,  
5 such that the gate insulation layer 112 covers the gate electrode 110 of the switching  
device TFT.

The passivation layer 140 covers the switching device TFT such that a portion  
of the drain electrode 130 of the switching device TFT is exposed.

The organic insulation layer 144 is formed on the passivation layer 140 such  
10 that the portion of the drain electrode 130 of the switching device TFT is exposed.

The pixel electrode 150 is formed on the organic insulation layer 144 such  
that the pixel electrode makes contact with the drain electrode 130 of the switching  
device TFT via a contact hole 141. The pixel electrode 150 comprises indium tin  
oxide (ITO) or indium zinc oxide (IZO), so that pixel electrode 150 is transparent and  
15 electrically conductive.

The retardation layer 152 is formed on the pixel electrode 150. The  
retardation layer comprises liquid crystal polymer that is hardened when an  
ultraviolet light is irradiated. For example, the retardation layer 152 includes  
cholesteric liquid crystal. The retardation layer 152 compensates a phase  
20 difference of a light that passes through the liquid crystal layer 300. The light may  
be generated from a backlight assembly (not shown) in a transmissive type liquid  
crystal display apparatus.

In a process of manufacturing the array substrate 100, a cholesteric liquid  
crystal material is coated on the pixel electrode 150. An ultraviolet light is irradiated  
25 onto the cholesteric liquid crystal material to fix an arrangement of cholesteric liquid

crystal molecules. Thus, the retardation layer 152 that operates as a biaxial film or uni-axial film is formed. When a polarized ultraviolet light is irradiated onto to the cholesteric liquid crystal material, the retardation layer 152 operates as the biaxial film. When a non-polarized ultraviolet light is irradiated onto the cholesteric liquid 5 crystal material, the retardation layer 152 operates as a C-plate film that belongs to the uni-axial film.

The first alignment film 160 is formed on the retardation layer 160.

FIGS. 11A through 11E are cross-sectional views showing a process of manufacturing an array substrate of FIG. 10.

10 Referring to FIG. 11A, a metal such as tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc. is deposited on a first transparent substrate 105 that has a material that is transparent and electrically non-conductive such as glass, ceramic or quartz.

15 The metal is patterned to form a plurality of gate lines (not shown) and gate electrode 110 protruding from the gate lines.

Not shown in FIG. 11A, when the gate electrode 110 is formed, a storage electrode may be formed together with the gate electrode 110.

Silicon nitride is deposited on the first substrate 105 with a gate electrode formed thereon, so that the gate insulation layer 112 is formed.

20 Amorphous-silicon and n+ amorphous-silicon are deposited in sequence and patterned to form a semiconducting layer 114 and an ohmic contact layer 116 at a position near the gate electrode 110.

A metal such as tantalum (Ta), titanium (Ti), molybdenum (Mo), aluminum (Al), chromium (Cr), copper (Cu), tungsten (W), etc. is deposited and patterned to form a 25 source line (not shown), a source electrode 120 and a drain electrode 130. The

source electrode 120 protrudes from the source line. The drain electrode 130 is spaced apart from the source electrode 120.

Then, a passivation layer 140 is formed.

Referring to FIG. 11B, an organic insulation layer 144 is coated on a result of FIG. 11A via a spin coating method. A contact hole 141 is formed such that a drain electrode 130 is exposed via the contact hole 141. The organic insulation layer 144 includes thermosetting plastic such as acrylic resin that is positive type photoresist. Thus, a portion onto which an ultraviolet light is irradiated in a photolithography process is eliminated in a developing process to form the contact hole 144.

Referring to FIG. 11C, a pixel electrode 150 is formed on an organic insulation layer 144. The pixel electrode 150 makes contact with a drain electrode 130 via a contact hole 141. Thus, the pixel electrode 150 is electrically connected to the drain electrode 130. The pixel electrode 150 has indium tin oxide (ITO) or indium zinc oxide (IZO). The indium tin oxide (ITO) or indium zinc oxide (IZO) may be deposited on an entire surface of the organic insulation layer 144, and patterned to form the pixel electrode 150. The indium tin oxide (ITO) or indium zinc oxide (IZO) may be deposited partially to form the pixel electrode 150.

Referring to FIG. 11D, a cholesteric liquid crystal material is coated on the pixel electrode 150. An ultraviolet light is irradiated onto the cholesteric liquid crystal material to fix an arrangement of cholesteric liquid crystal molecules. Thus, the retardation layer 152 that operates as a biaxial film or uni-axial film is formed. When a polarized ultraviolet light is irradiated onto to the cholesteric liquid crystal material, the retardation layer 152 operates as the biaxial film. When a non-polarized ultraviolet light is irradiated onto the cholesteric liquid crystal material, the retardation layer 152 operates as a C-plate film that belongs to the uni-axial film.

The retardation layer 152 may be formed via a spin coating method, a micro gravure coating method or a capillary coating method. Preferably, the retardation layer 234 is formed via the micro gravure coating method or the capillary coating method.

5 The retardation layer 152 may include reactive mesogen mixture (RMM), polyvinylalchol (PVA), polycarbonate (PC), or cycloolefin polymer (COP).

Referring to FIG. 11E, an alignment film 160 for pre-tilting liquid crystal molecules is formed on the retardation film 160.

An array substrate 100 is formed via a process of manufacturing described  
10 above. The array substrate 100 is assembled with a color filter substrate 200. The liquid crystal layer 300 is interposed between the array substrate 100 and the color filter substrate 200.

As described above, a retardation layer interposed between the pixel electrode and the alignment film takes the place of the retardation film of a general  
15 liquid crystal display apparatus, which is disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.

Therefore, a number of films for the liquid crystal display apparatus and a number of processes are reduced to save a manufacturing cost.

Having described the exemplary embodiments of the present invention and its  
20 advantages, it is noted that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by appended claims.

An ultraviolet light is irradiated onto liquid crystal polymer layer to form a retardation layer. The retardation layer is formed in a liquid crystal display panel  
25 that includes a color filter substrate, an array substrate and a liquid crystal layer.

The retardation layer may be formed on a color filter layer, protection layer or a common electrode of the color filter substrate. The retardation layer may be formed on a pixel electrode of the array substrate.

The retardation layer interposed between the pixel electrode and the  
5 alignment film takes the place of the retardation film of a general liquid crystal display apparatus, which is disposed over the color filter substrate or under the array substrate, so that the retardation film is not necessary.